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# *Data Transmission over Power Line with Lightning Protection Devices*

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## Abstract

This paper discusses comparative analysis of the effects of surge protection devices (SPD) upon the power line communication channels. The quality of the data transmission channel is measured based on the data rate for the various channel parameters which include channel length and application method of the lightning protection device. The performance measurements are also carried out for various lengths of the communication channel. Experiment results show that specific combination of SPDs applied in the network causes severe degradation of the channel quality which is associated with the combination of grade levels and channel lengths.

**Key words:** Data transmission, power line communication, surge protection

## 1. INTRODUCTION

The power-line communication networks aims at the data transmission through the media of electrical power transmission lines whose infrastructures have already been deployed relatively wide areas in most of the regions. There have been many research works for the characterization of the power line as a communication medium in an effort to find the suitable modulation and error correction method [1]. Recently the transmission technologies and the various types of broadband application are being emerged for the power line networks. The multimedia communication, internet access and smart grid data networks over power-lines are some of the representative application examples. In general broadband communication requires more channel bandwidth which is more vulnerable to multipath propagation effects. These high data rate systems are affected by severe inter-symbol interference due to the frequency selective fading [2]. In the broadband power line communication channel this fading is closed related to the impedance of the load connected to the power system.

Surge protection devices (SPD) are installed to protect from the disorder of electricity the electric and electronic systems consisting of various types of electrical loads in the power line networks. The SPD which is made of ZnO varistor is one of representative devices widely installed in the field. This device is categorized into various kinds depending on the lightning protection level. This grade level defines the location of installation in the power transmission system [3-4]. Related technical standards are being developed in Korea which mandates the installation of SPD on the power system. This provision necessitates thorough evaluation of the effect of the SPD on the communication channel which might be embedded in the power line.

Related research works already show the impact of SPD on the power-line communication. It is also known that the varistor is related to the loss of transmission of power-line communication [5]. However, more detailed impacts need to be studied due to SPD's grade level and the power line length to predict the effect of the installation and furthermore find out the cause of the performance degradation. This paper discusses the experimental results which measure the data rate performance under selective combinations of SPD and the lengths of the data transmission line.

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## 2. PERFORMANCE MEASUREMENTS

The test system is composed for varying power line lengths (1m, 50m and 100m). Lightning protection zones (related to the class 1, 2 and 3) are also defined at the transmitting and the receiving end, which are located on the routes of data transmission of the power line communication system. The power of single phase 220V is assumed to be supplied and the OFDM (Orthogonal Frequency Division Multiplexing) scheme based high-speed power line communication modem for single phase was selected for the experiment [6]. The OFDM is one of the advanced transmission technologies which has been already adopted in various areas including wireless local area, digital audio and video broadcasting systems and advanced cellular networks [7-8]. The advantage of the OFDM when it is applied to the power line channel is that this system can combat the various types of narrow band interferences utilizing the subcarrier based data delivery. The PCs are installed to generate the data and to monitor the transmission data rates.

In addition, the ground-type plugs are connected to the voltage-limiting varistor in the SPD with grade 1, 2, and 3 as represented in Fig. 1. In this figure the number indicated on the labels for SPD represents the grade of the SPD. The location of the installation is labeled either as 'T' representing transmitter side or 'R' for receiver end. For example the label 'T2' means the SPD with grade 2 is installed for the experiments. The electric power of single phase 220V is assumed to be supplied and the OFDM based high-speed power-line communication modem for single phase was selected for the experiments. The electric power supplied is isolated from the test system to reduce impacts of changes in load impedance which is related to the channel spectrum shapes. Two high-speed power line communication modems are connected to the computers at the transmitter and the receiver, respectively. One end sends the data and the other receives data.

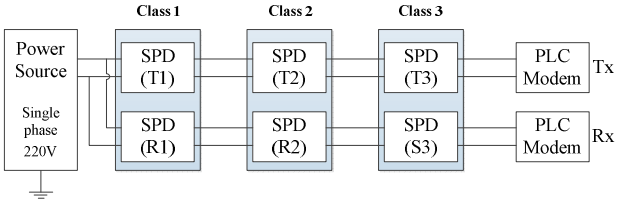


Fig. 1. Test system model for performance measurements

## 3. RESULTS

Experiment results are summarized in Fig. 2 which shows the performance of power line communication in terms of the data transmission rate for the various combinations of the SPD grade and the line length.

In case of power line length of 1 m with all of the SPDs of grade 1, 2, and 3 applied both to the transmitter end and the receiving end, there are 50% loss of data transmission rate compared to the state of no application of SPD. In cases of power line length of 50 m and 100 m, the effect of SPD grade is more sensitive. For example in 100 m case, the power line communication is blocked when grade 3 is present regardless of the location in the network. This phenomenon occurs in the 50 m case in the similar manner. The overall results show that the performances are more sensitive to the higher grade and longer transmission line length.

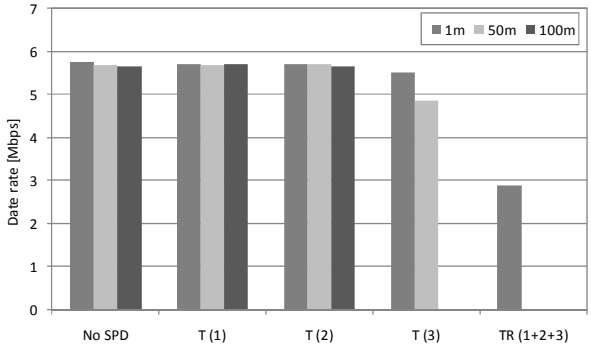


Fig. 2. Comparison of data rate for SPD installation method

## 4. CONCLUSION

This paper discusses the effects of the SPD and line lengths on the power-line communication network. The measurements are performed for various combinations of SPD grades for representative channel lengths. The performance comparison is carried out based on the data transmission rate of power-line communication through the OFDM adopted high-speed power-line communication modem. When the SPD of grade 3 is installed the data rate degradation is more severe than the other grade cases. This trend is similar regardless of the location of the installation of the grade 3 and the length of the transmission line. Further research works are needed to find out the causes of the sensitivity to the higher grade SPDs and solutions to overcome this impediment to the high quality data transmission.

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